Accelerated Testing Validation

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Project ID #
FC016

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Project Overview

Timeline

- Project Start Date
  - **August 2009**
- Project Duration
  - **4 Years (1 year extension)**
- Project End Date
  - **Sept. 2014**

Budget

- Total project funding
  - 5 Years : $4,409,790
  - DOE Cost : $4,350,000
  - Cost Share : $159,790
- Funding for FY13/FY14

LANL	$ 750k, 350k
Partners (Industry)	$ 98k,
Other National Labs	$ 172k, 150k
FY13/FY14 Total	$1020k, 500k

Barriers

Fuel cells: 2011 Technical Plan

A. Durability

Automotive Target

5,000 hours (10% degradation)

Stationary Targets

2017 : 40,000 hours (20% degradation)

2020 : 60,000 hours (20% degradation)

Bus Target

2016 : 18,000 hours

Accelerated testing protocols need to be developed to enable projection of durability and to allow for timely iterations and improvements in the technology.

Partners

- Ballard Power (System Integrator)
- Ion Power (Materials Supplier)
- ORNL (Metal Bipolar Plates)
- LBNL (Modeling)

Objectives/Barriers - Relevance

The objectives of this project are 3-fold

1. Correlation of the component lifetimes measured in an AST to real-world behavior of that component.
2. Validation of existing ASTs for Catalyst layers and Membranes
3. Development of new ASTs for GDLs, bipolar plates and interfaces

Technical Targets

Automotive : Durability with cycling: 5,000 hours (2010/2015): 2005 Status (2000 hours for stack and 1000 hours for system)

Stationary : Durability: 40,000 hours (2011): 2005 Status = 20,000 hours

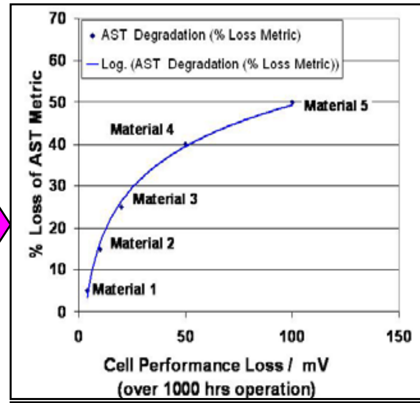
Bus Data : 18,000 hours (2016); 25,000 hours (ultimate); Status = 12,000 hours.

Importance of Accelerated Stress Test (AST)

- Allows faster evaluation of new materials and provides a standardized test to benchmark existing materials
- Accelerates development to meet cost and durability targets
- Different ASTs are available (DOE-FCTT, USFCC and JARI)
  - Lack of correlation to “Real World” Data
  - No tests available for GDLs and other cell components
  - Value of combined vs individual tests

Approach

Materials
• BPS provides materials used in Bus Stack
• W. L. Gore provides commercial MEAs
• Ion Power provides custom MEAs
• SGL carbon provides commercial GDL materials
• ORNL provides metal bipolar plates



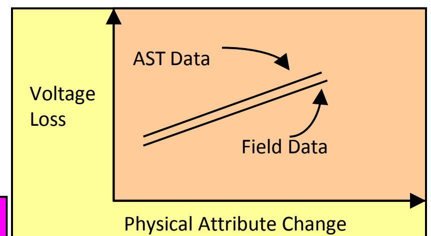
LANL performs DOE-FCTT ASTs
Develops GDL, bipolar plate ASTs

Characterization
Fuel Cell Performance
VIR, Impedance, HelOx, Modeling
Catalyst
• ECSA, Mass activity, particle size, layer thickness, composition, loading
Membrane
Cross-over, shorting resistance, HFR, thickness
GDL
•Impedance, Hydrophobicity

Electrocatalyst AST
C - Corrosion AST
Membrane AST
GDL AST

BPS Bus Fleet Data
• Voltage degradation distribution data from P5 fleet & HD6 Module
• Cell Data (36 Cells)
• MEA Characterization (108 MEAs)

LANL Drive Cycle Testing
• Automotive drive cycle testing
• RH, Temp, Pressure effects



Statistical Correlation
• Relate field and AST data to physical attribute change
• Good correlation if AST slope similar to "Real World Data" slope

Goals
• Recommend improved catalyst and membrane ASTs that correlate to real world data
• Recommend ASTs for GDL and bipolar plate materials
• Co-ordinate efforts with FCHEA and USDOE-FCTT

Approach - Milestones

1	Q1	12/31/2013	Complete comparison of DOE FCTT ASTs for carbon corrosion (1.2V hold and 1.0 to 1.5V cycles) and record the differences	Complete (≈ 100 times faster decay rates)
2	Q2	3/31/2014	Demonstrate GDL AST results that have comparable GDL degradation as those observed in an approximately 1000 hour fuel cell drive cycle test	Complete (Performance is MEA dependant)
3	Q3	6/30/2014	Propose AST for membrane degradation and quantify acceleration factor with respect to drive-cycle data. Verify that AST has at least an acceleration factor of 10	On track
4	Q4	9/30/2014	Propose AST for catalyst degradation and quantify acceleration factor with respect to drive-cycle data. Verify that AST has at least an acceleration factor of 10	

Materials Used in this Project

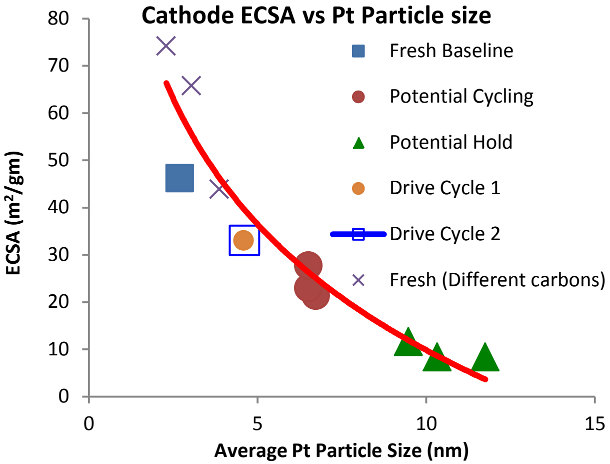
- Gore™ MEAs
  - Gore™ Primea® MESGA MEA A510.1/M720.18/C510.2
  - Gore™ Primea® MESGA MEA A510.2/M720.18/C510.4
  - Gore™ Primea® MESGA MEA A510.1/M710.18/C510.2
- Ballard P5 and HD6 MEAs
- Ion Power MEAs
  - DuPont™ XL membranes
  - Tanaka Catalysts
    - TEC10E50E, TEC10E40E, TEC10E20E, TEC10E10E, TEC10E05E (High Surface area carbon 50 wt%, 40 wt% and 20 wt% Pt)
    - TEC10V40E, TEC10V20E, TEC10V10E, TEC10V05E (Vulcan carbon 40 wt%, 20 wt%, 10 wt%, and 5 wt% Pt)
    - TEC10EA40E, TEC10EA20E, TEC10EA10E, TEC10EA05E (Low Surface area carbon 40 wt%, 20% wt%, 10 wt%, and 5 wt% Pt)
- GDL
  - SGL SIGRACET® 24BC (5% PTFE-substrate/23% PTFE MPL; 84% substrate porosity)
  - SGL SIGRACET® 25BC (5% PTFE-substrate/23% PTFE MPL; 88% substrate porosity)
  - Varying PTFE content and substrate porosity

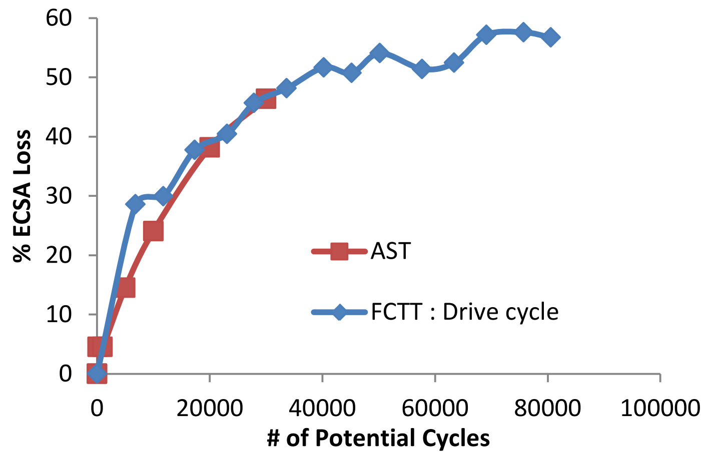
M710 : Discontinued product. Lower chemical and mechanical durability sample

M720 : technology circa 2005. Higher chemical and mechanical durability sample

Correlation of AST, Field Data and Drive Cycle

Electro-catalyst AST





Start/stops is the primary correlation to performance decay. Consistent with low number of > 100 mV transients

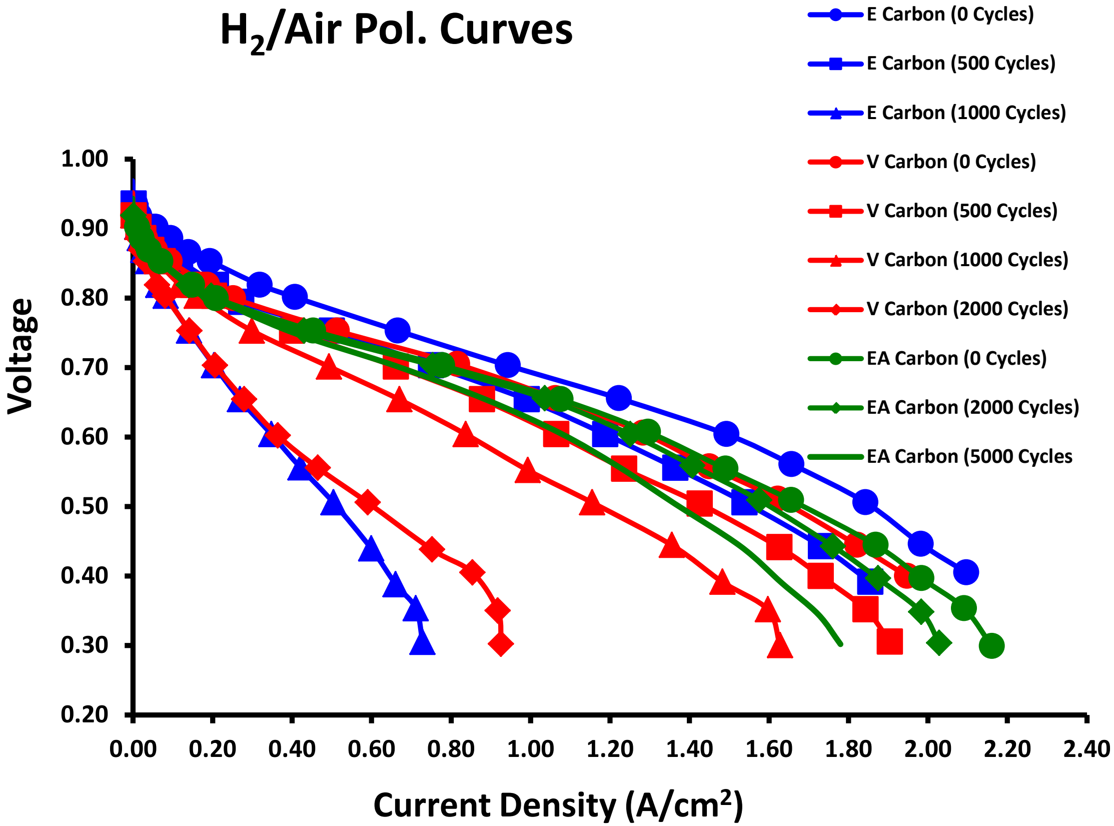
System	P5 (1)	P5 (2)	P5 (3)	HD6
Hours of operation	2769	3360	2597	6842
Degradation rate (BOL to EOL) @ ≈ 0.5 A/cm2 (μV/cell/hr)	31.4	33.5	26.3	5.2
≈ Transients ≥ 100 mV	225	270	350	1100
Total # of Air/Air Starts	361	417	263	< 100
Voltage (%cycle > 0.8V/cell)	52	48	53	57

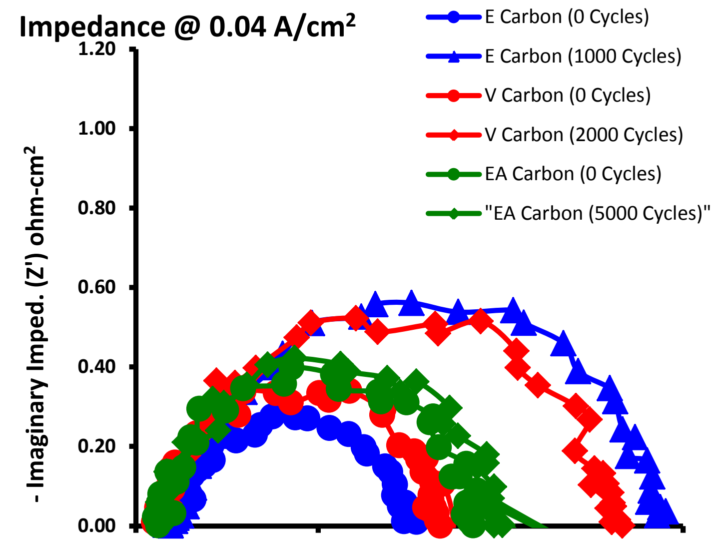
- 30,000 cycles ≈ 133 hours.
- Try modified FCCJ protocol instead of DOE's triangular wave

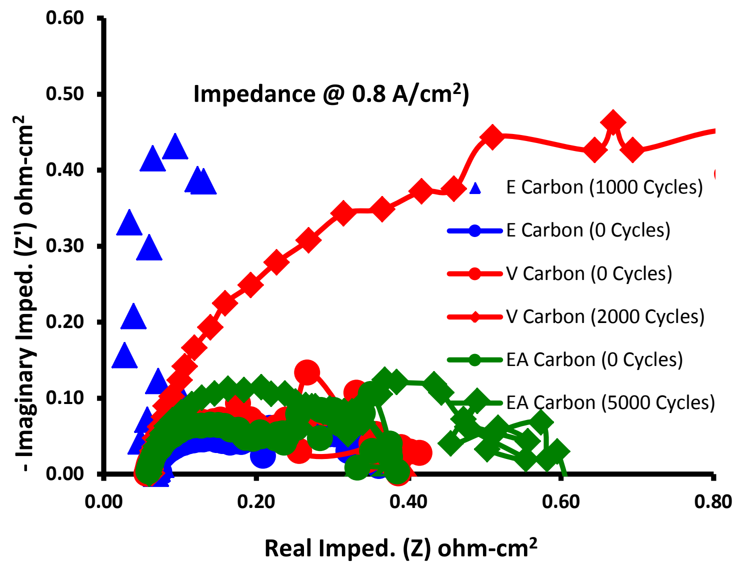
- 30,000 cycles ≈ 2000 hours of bus operation (Both P5 and HD6)
- 30,000 cycles ≈ 850 hours of US DRIVE Drive-Cycle
- 30,000 cycles ≈ 500 hours of wet drive cycle
- 5000 hours ≈ 175,000 cycles
- Need >> 30,000 cycles for 5000 hour automotive durability

New FCTT AST (1 to 1.5V cycle) : Performance

Support AST



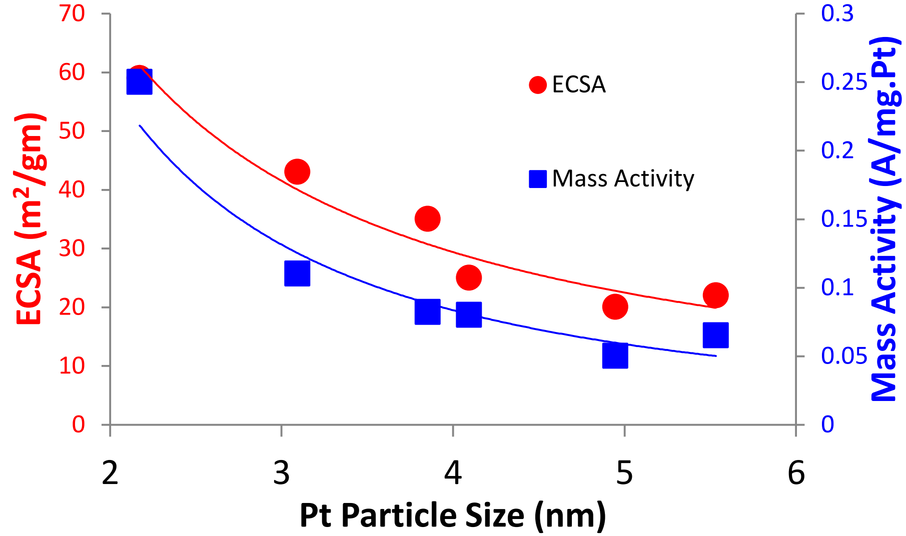


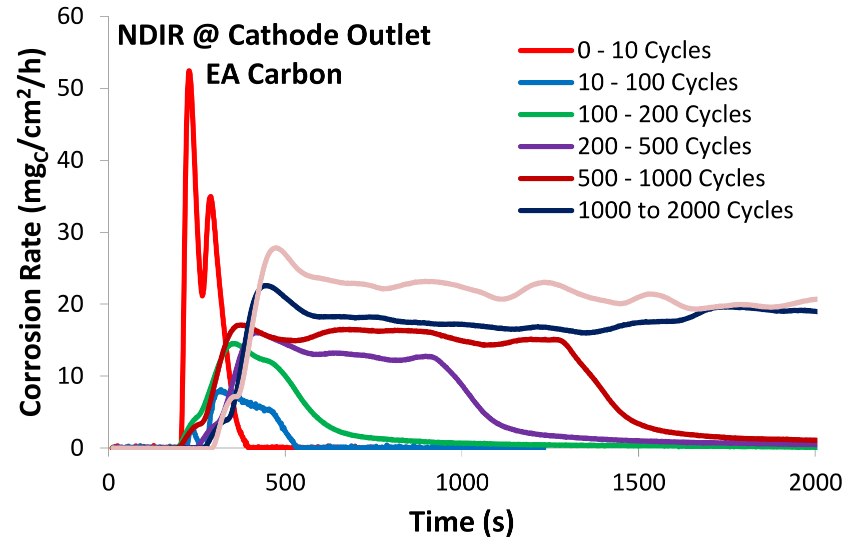


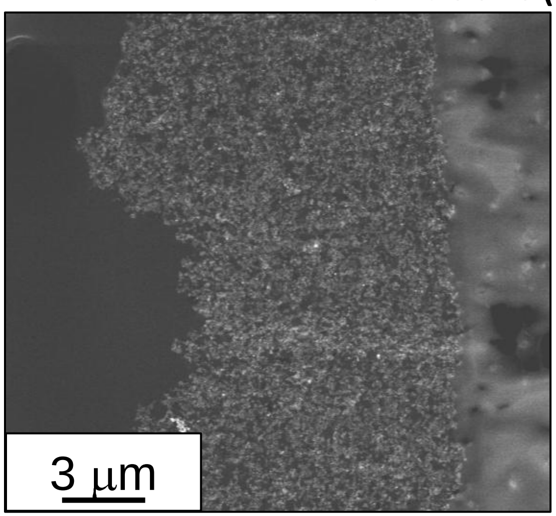
- AST has excellent ability to distinguish carbons
- Kinetic and mass transport losses increase with AST cycling time

New FCTT AST (1 to 1.5V cycle) : Diagnostics

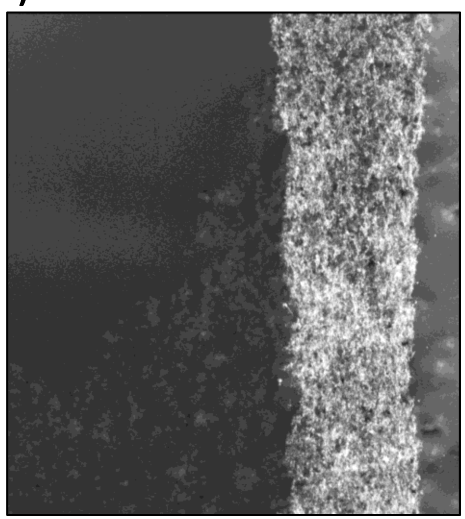
Support AST







Fresh

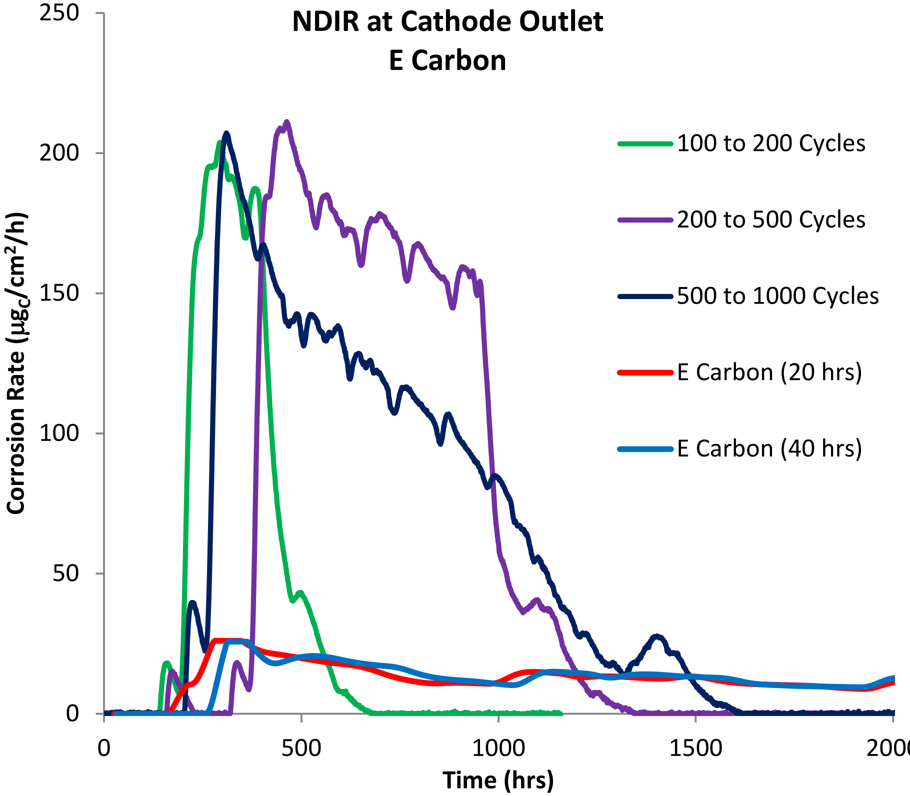


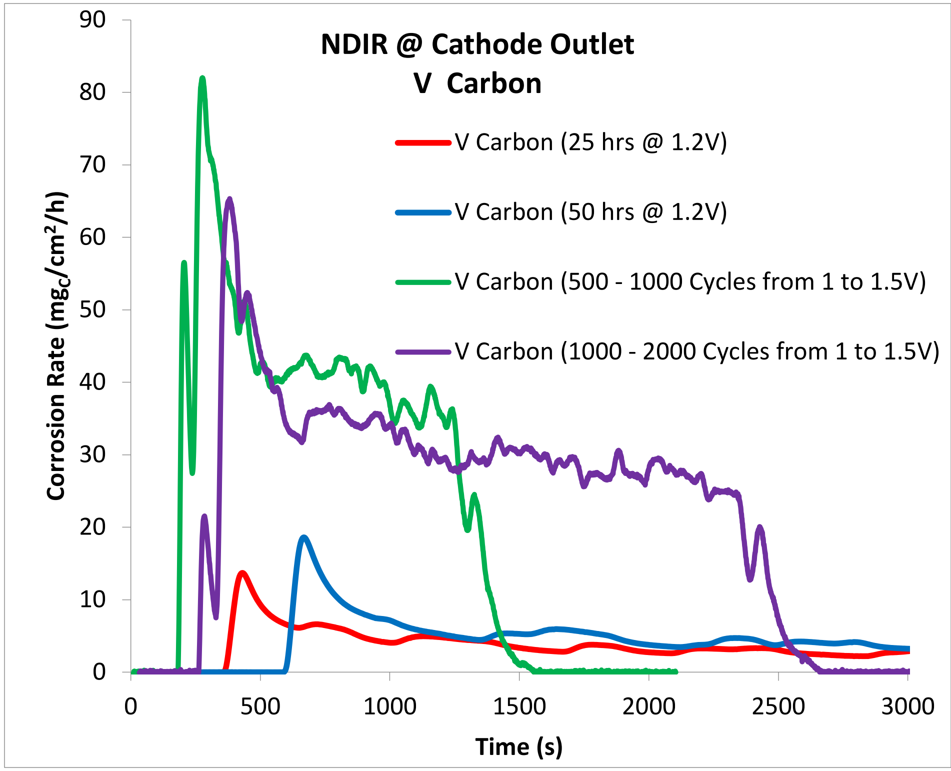
Aged 400 hrs @ 1.2V (V-Carbon)

- Kinetic losses correspond to Pt particle size increases
- Mass transport losses correspond to carbon loss and associated compaction
- Corrosion rate increases with time initially and then decreases with further carbon loss

Compare New and Old AST: Amount of C Corroded

Support AST





- Approximately 1 order of magnitude greater carbon corrosion rate
- Correlates to decrease in catalyst layer thickness and increased catalyst layer compaction associated with increased mass transport resistance

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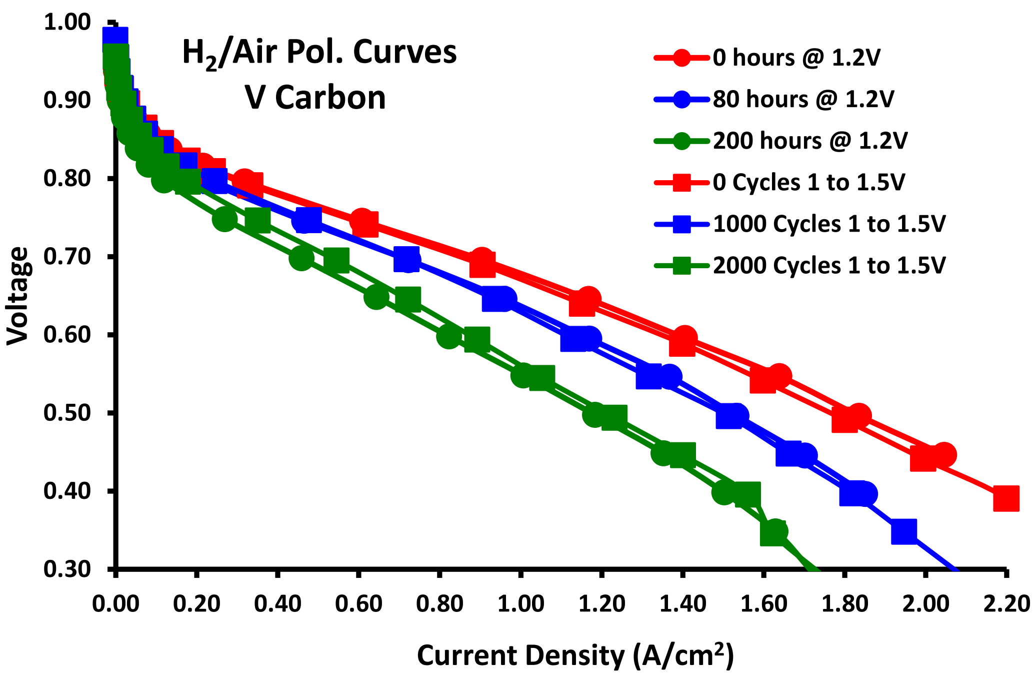
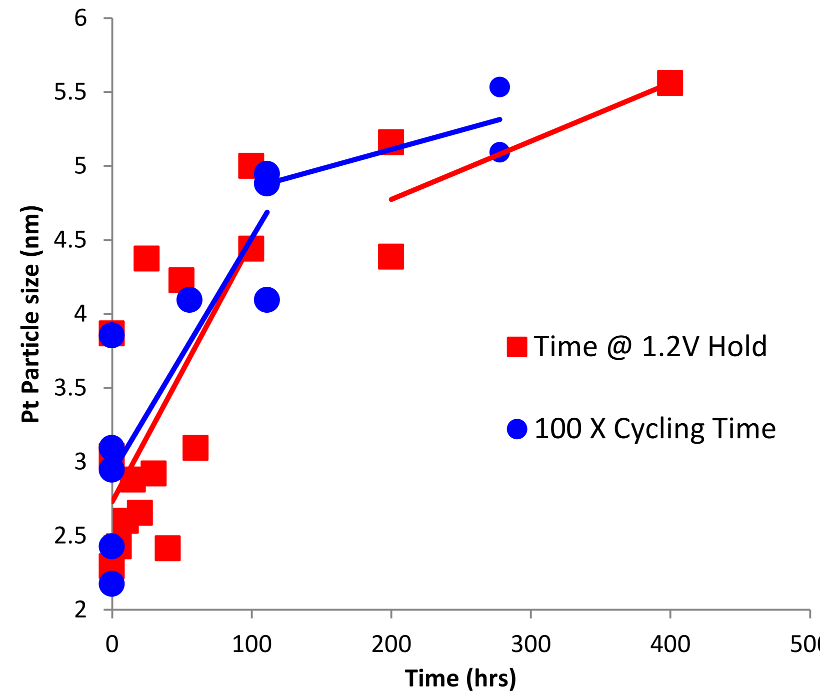
Compare new and old AST : Catalyst Sintering

Support AST





- ≈ 150 times faster decay in fuel cell performance
- ≈ 100 times faster Pt growth rate during cycling
- Faster decay rate initially and tapering later as you corrode more carbon and stabilize the Pt particle size at around 5 nm

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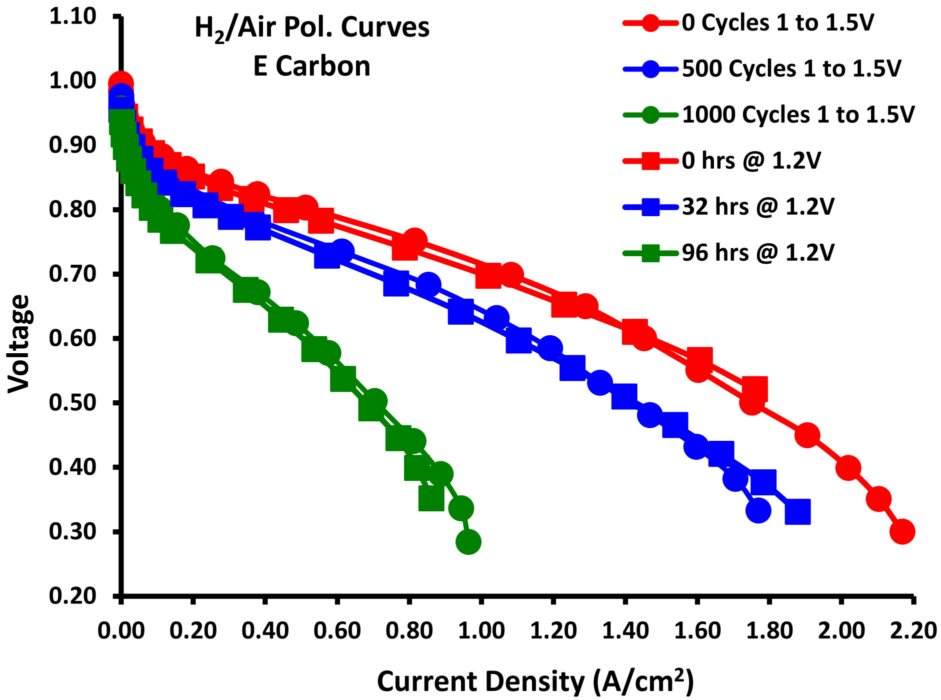
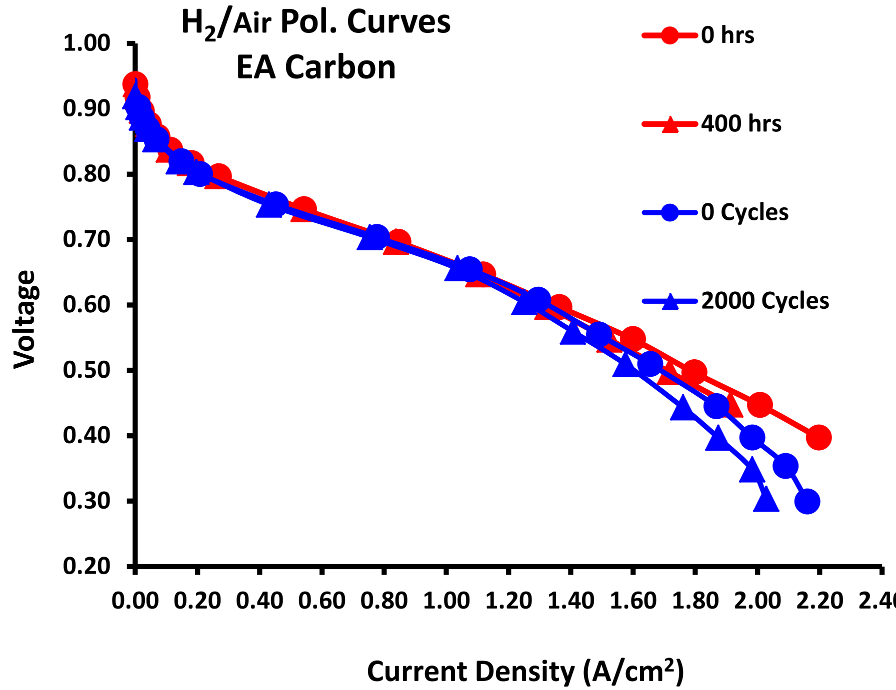
Accomplishments /Progress

Compare new and old AST : Performance

Support AST





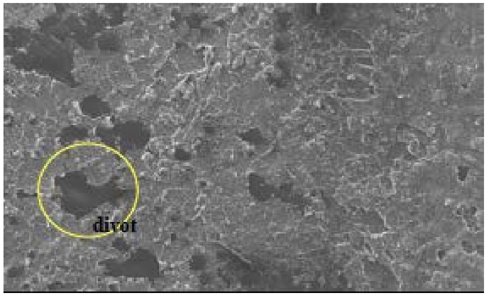
- ≈ 150 times faster decay in fuel cell performance on multiple carbon types
- ECSA and Mass activity decay also enhanced by ≈ 150 times

- New AST is faster and retains the same degradation mechanism. Should also correspond to # of worst case scenario unmitigated start/stops

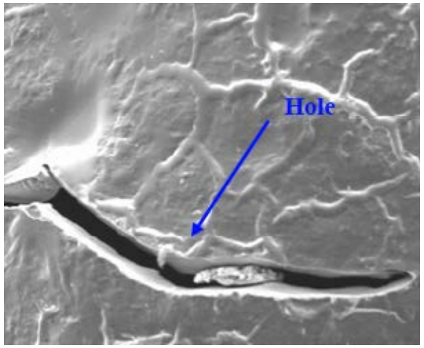
Membrane Degradation : Damage Mechanisms

Membrane AST

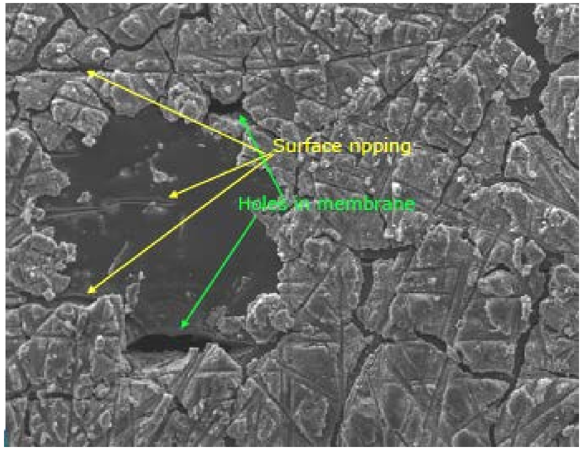
HD6 Field Sample

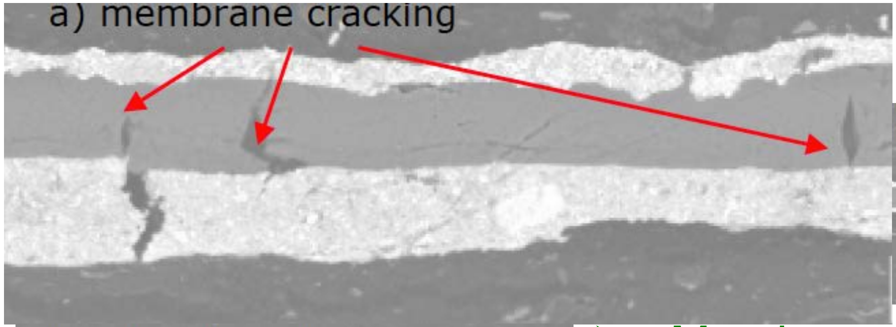


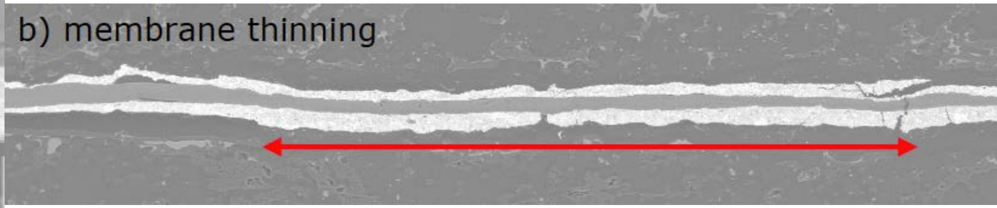
P5 Field Sample

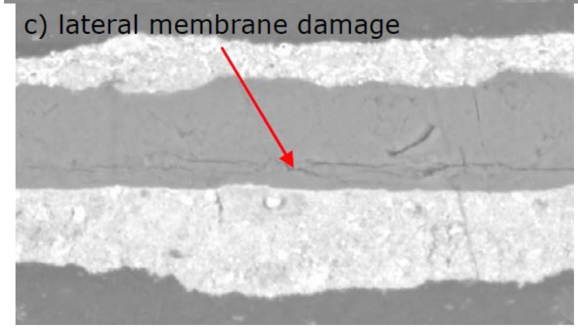


P5 sample after H_2/Air RH cycling AST





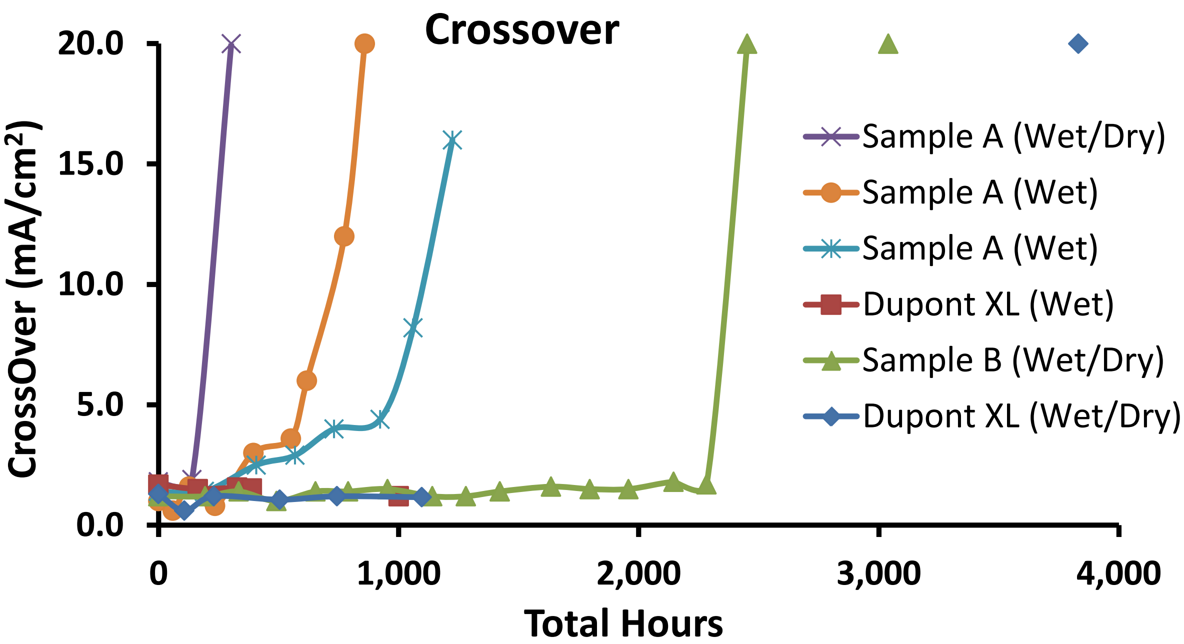


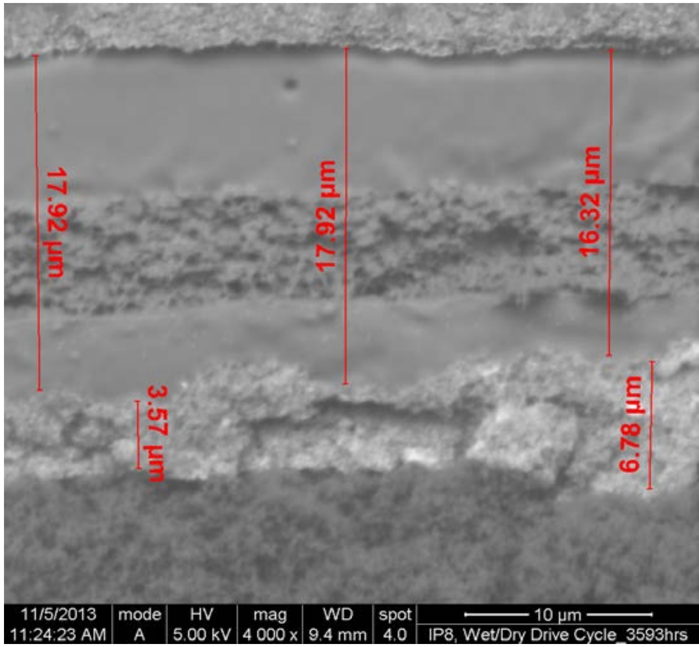


- Membrane global thinning due to chemical degradation (accelerated by OCV under dry conditions)
- Membrane cracking and local thinning due to mechanical stresses (accelerated by RH cycling)
- Field sample can be replicated only by combined mechanical/chemical degradation

Membrane Degradation : FCTT Drive Cycle

Membrane AST



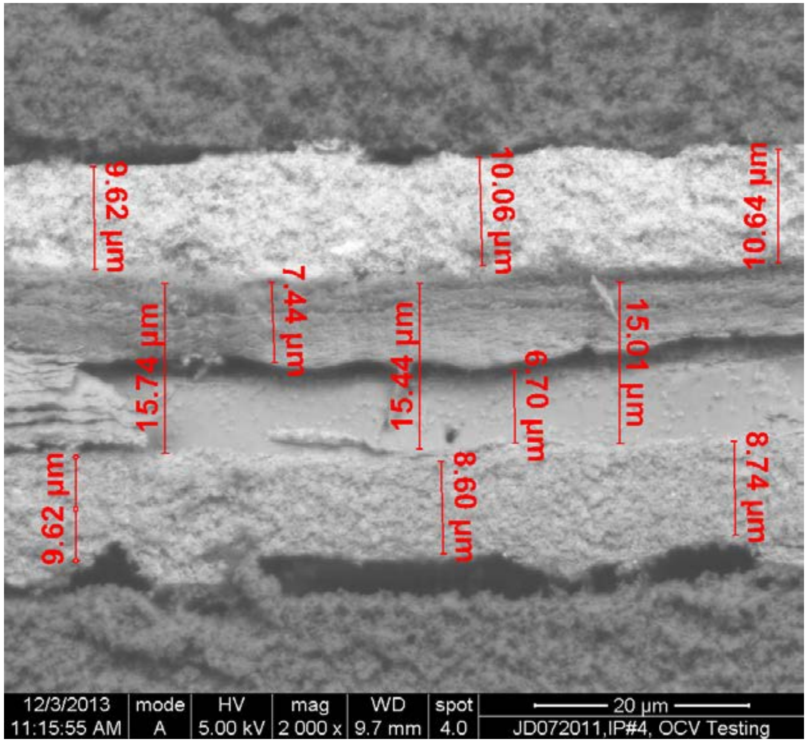


- Membranes without chemical and mechanical stabilization fail early in the drive cycle tests (< 500 hours) and fail even under wet only testing (< 1000 hours)
- Membranes with chemical and mechanical stabilization (DuPont™ XL) last > 2500 hours
  - ✓ One sample failed at 2300 hours due to test stand failure
  - ✓ The DuPont™ XL membrane failed at the edges due to absence of sub gasket
    - ✓ After 3800 hours: ≈ 30% thinning (mainly on cathode side of support)

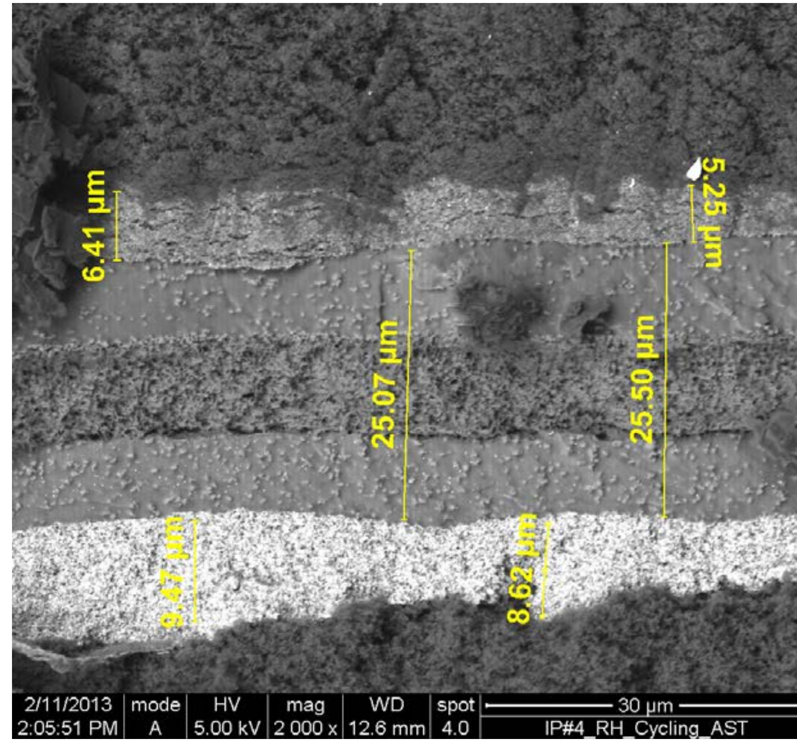
Current Membrane ASTs : Damage Mechanisms

Membrane AST

DuPont^{TM} XL 307 hours @ OCV



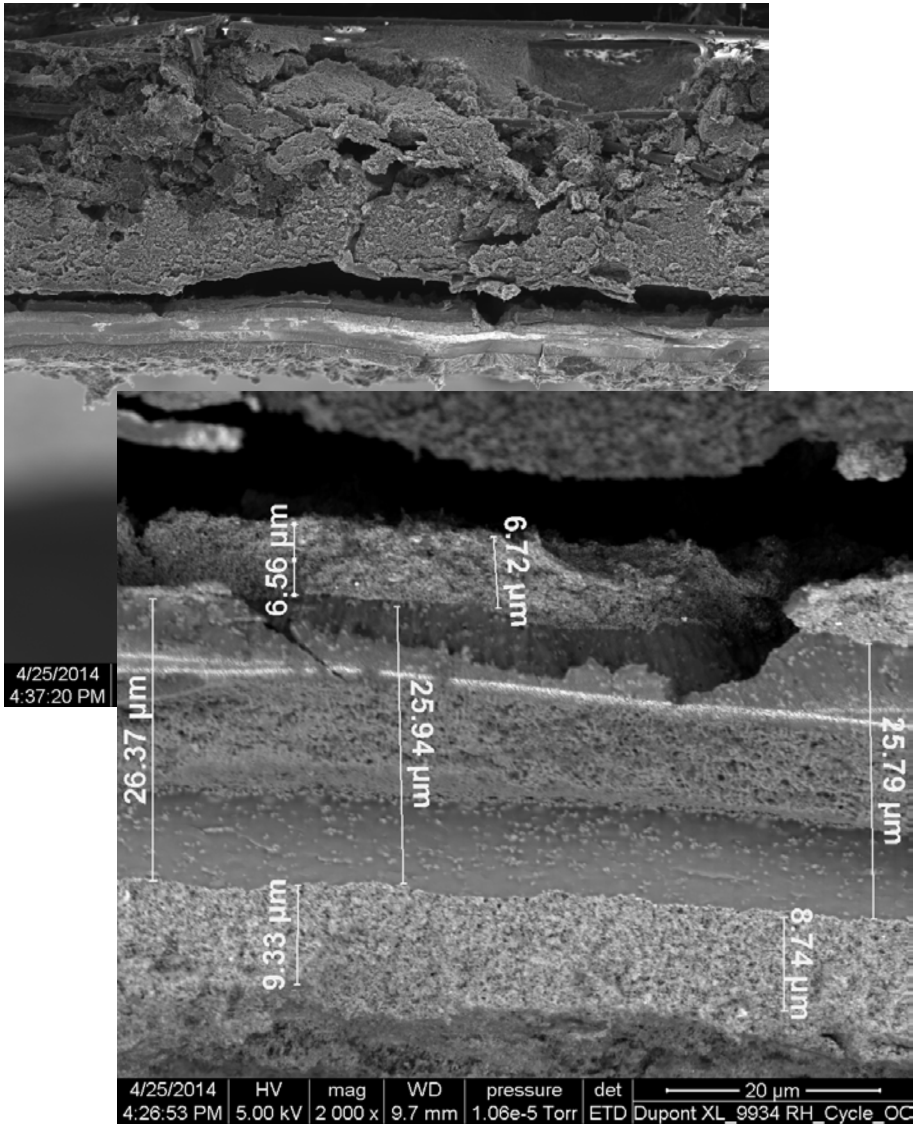
DuPont^{TM} XL 20098 RH Cycles



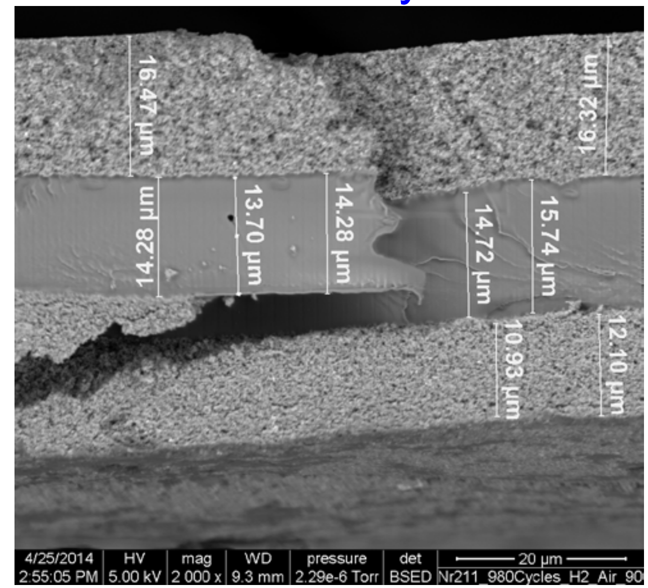
- Chemical Degradation (OCV @ 90 ^{o}C, 30% RH)
  - ✓ Cathode side of membrane is completely missing after 307 hours of OCV
  - ✓ More severe compared to drive cycle and field data
- Mechanical Degradation (RH cycling @ 80 ^{o}C in Air)
  - ✓ No visible degradation after 20,000 RH cycles
  - ✓ Most supported membranes are untouched by this AST

Proposed Membrane AST : Damage Mechanism

DuPont™ XL 9934 Cycles Membrane AST



N211 980 Cycles



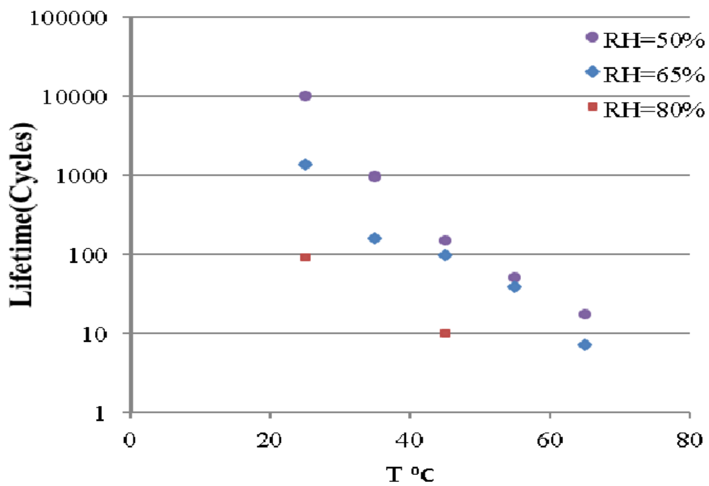
- RH Cycling in H_2/Air. Cell = 90 ^oC, Humidifier bottles = 92 ^oC (2 mins dry and 2 mins wet)
- Pt band in membrane observed
- Lateral cracks observed
- Membrane cracking observed
- Membrane thinning observed only in un-stabilized membranes

Proposed Membrane AST : Modeling

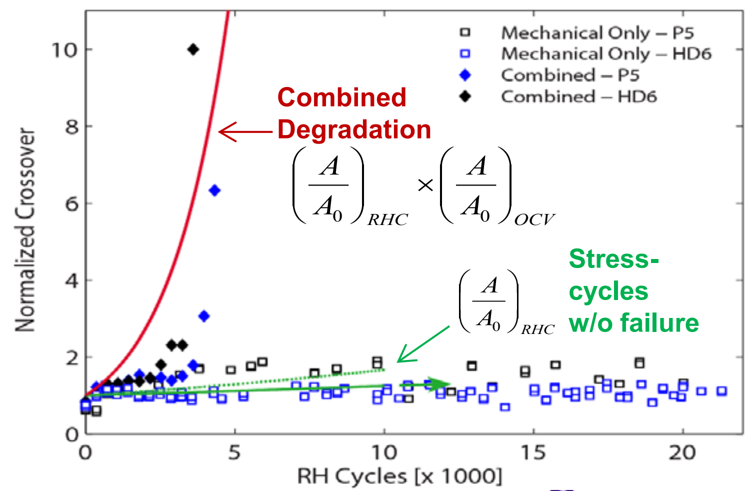
Membrane AST

	vs. Field	
	Dry	**Liquid**
RH Cycling **Mechanical**	Different	**Similar**
Chemical AST	**Similar**	More Severe
RHC @ OCV **Mechanical /Chemical**	**Similar**	**Similar**

RH cycling



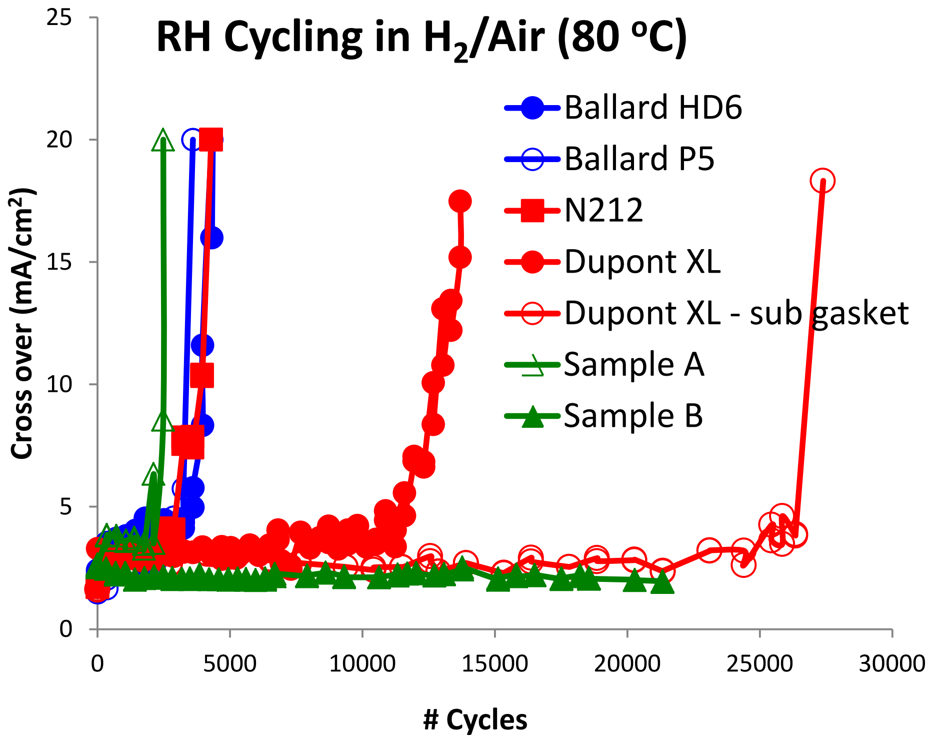
Combined cycling

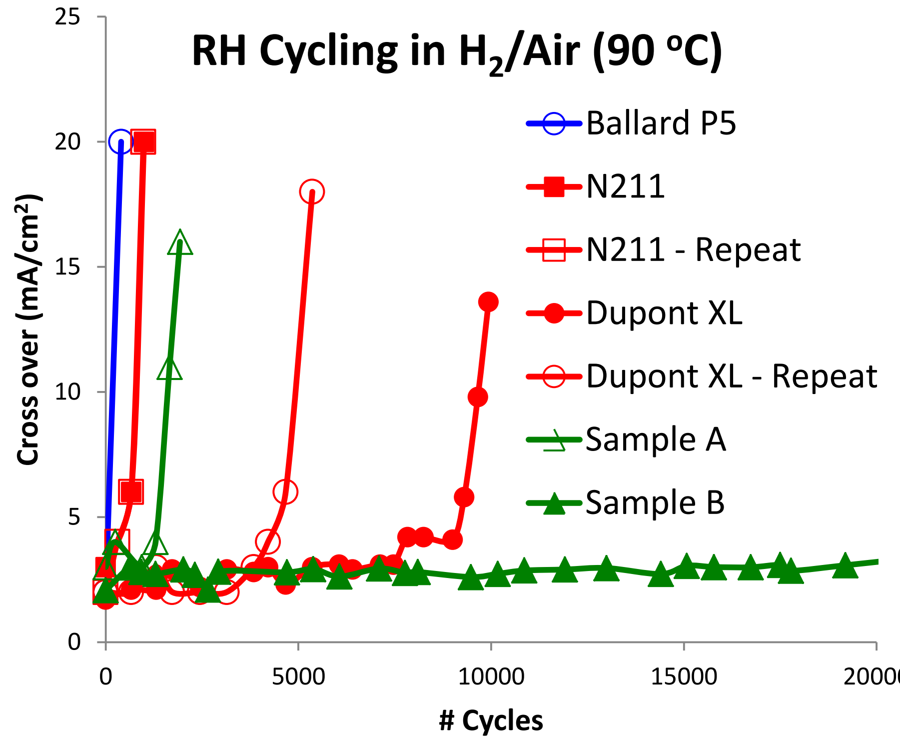


- SAXS: Field data similar to H_2/Air RH cycling AST
- Stress assisted void growth model developed at LBNL showing relevance of combined chemical/mechanical AST
- Temperature can be used as an accelerating factor

Proposed Membrane AST : Operating Conditions

Membrane AST





- RH cycling under OCV @ 80 °C: Stabilized membranes last > 55 days (20,000 cycles)
- RH cycling under OCV @ 90 °C: Thinning of N211 observed but still no thinning of DuPont™ XL. Need to accelerate chemical degradation with respect to mechanical
- Increase time of dry cycle with respect to wet cycle keeping total cycle time constant

GDL Degradation : Reported Work

GDL AST

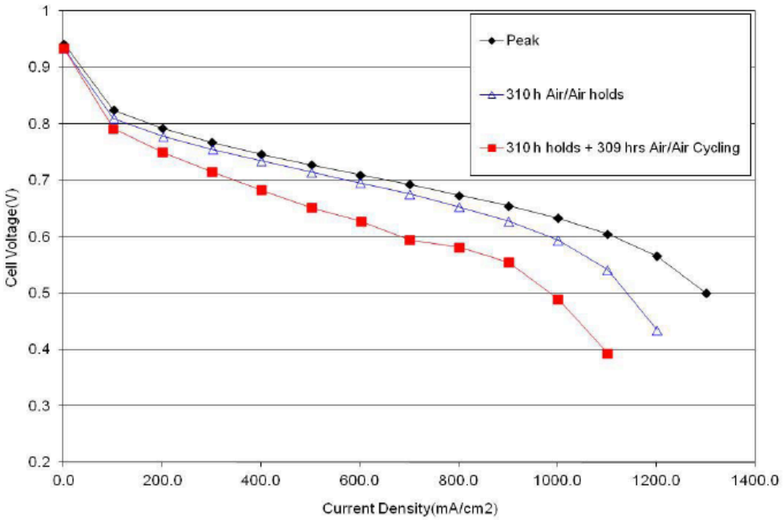


Figure 3. Hydrogen-air polarization curves before and after Air/Air exposure for the same cell shown in Fig. 2.

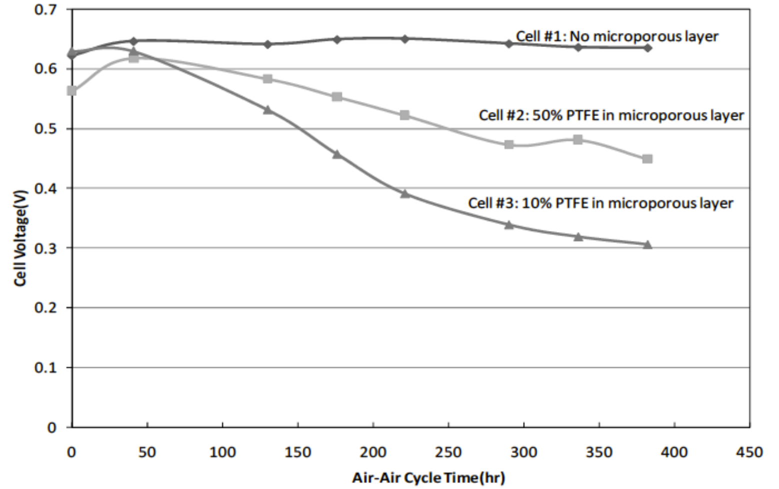


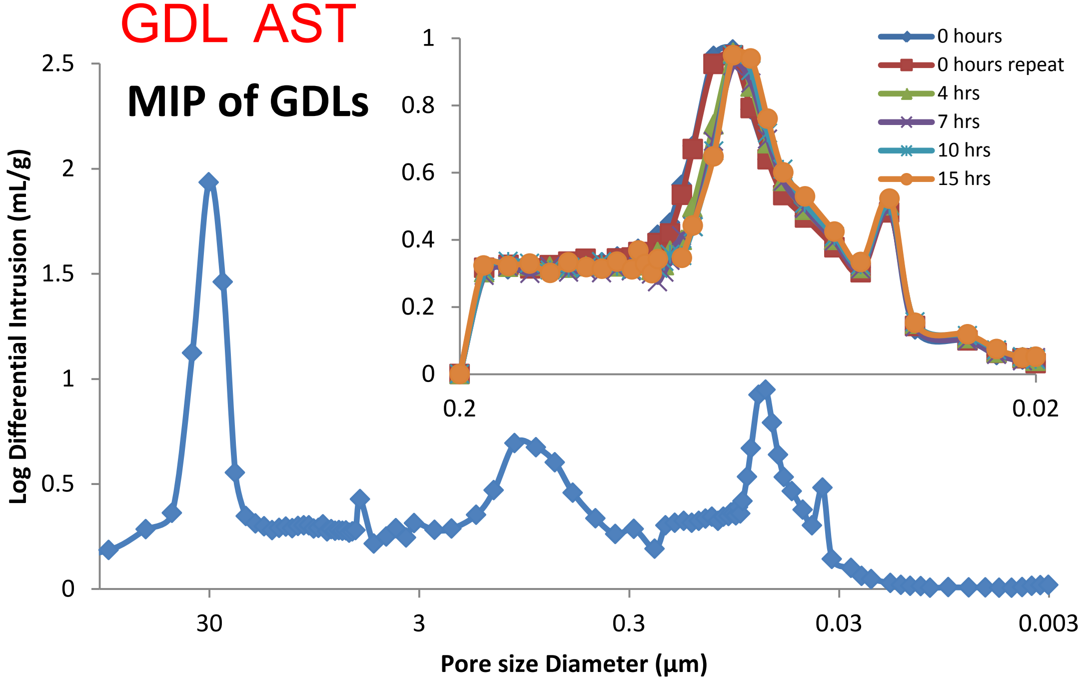
Figure 4. Cell performance measured at 1 A/cm^2 after exposure of 3-cell stack to air/air cycles (Table I protocol). Cell 3 is identical to cell described in Fig. 2. Cells # 1 and 2 are identical to cell # 3, except for the cathode GDLs, which is described in Table II.

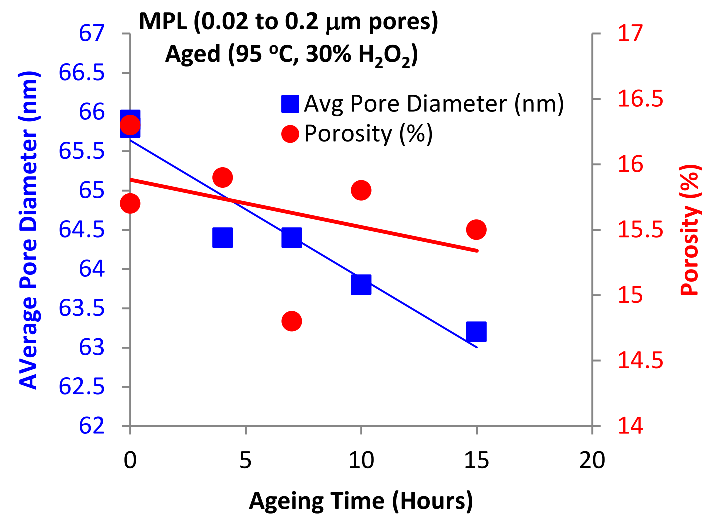
M. L. Perry et al, ECS Transactions, 33(1), 1081 (2010)

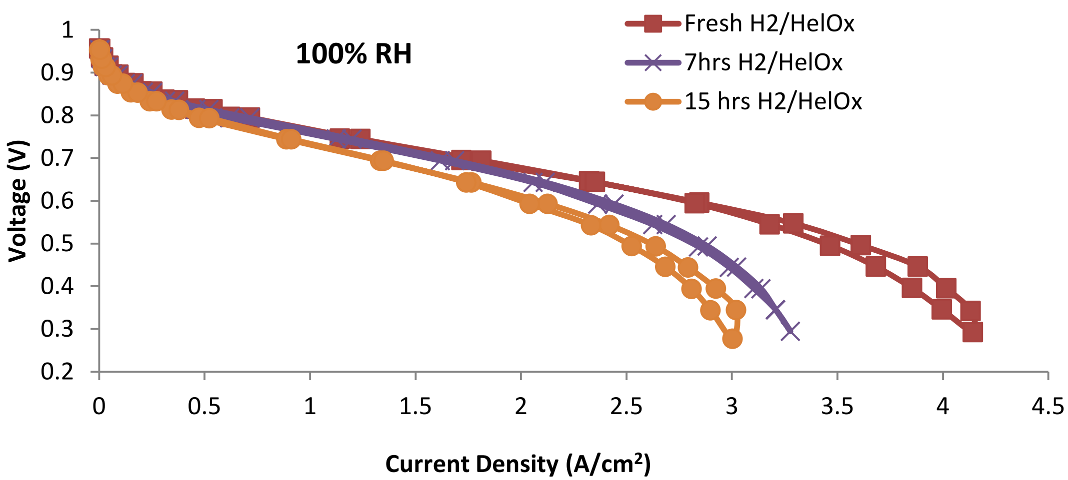
- GDL degradation is prominent at low Pt loadings, very thin/very thick catalyst layers and under wet/cool conditions
- UTRC has published data showing MPL degradation is an issue during Air/Air holds
- GDL AST reported by Decode project, Peter Wilde: SGL Carbon
  - Boil in 30%H_2O_2 @ 95 ^oC

Previously Reported GDL AST

GDL AST







- Boil in 30%H_2O_2 @ 95 ^oC
- Aged GDLs show loss in hydrophobicity (decrease in contact angle)
- Aged GDLs show decreased porosity in the MPL
- GDLs aged in peroxide show increased mass transport resistance in fuel cell applications

GDL Degradation : In Situ vs Ex Situ

Accomplishments /Progress

GDL AST

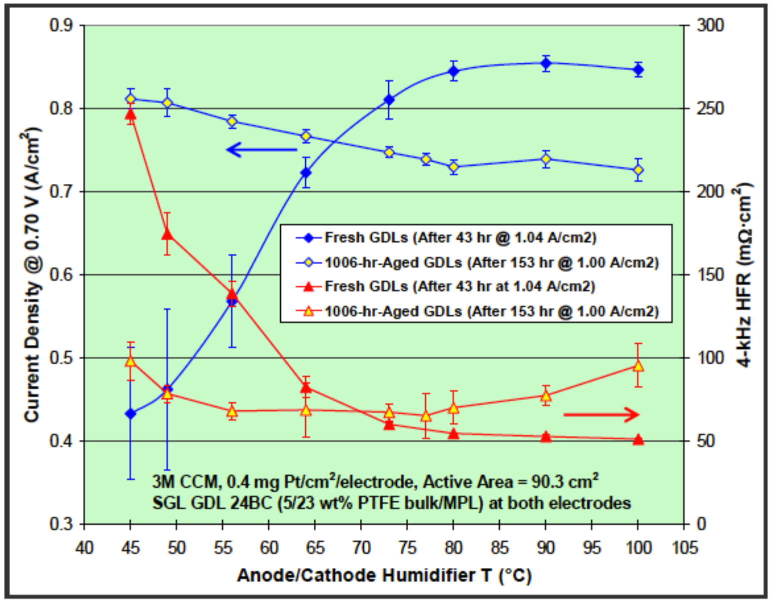
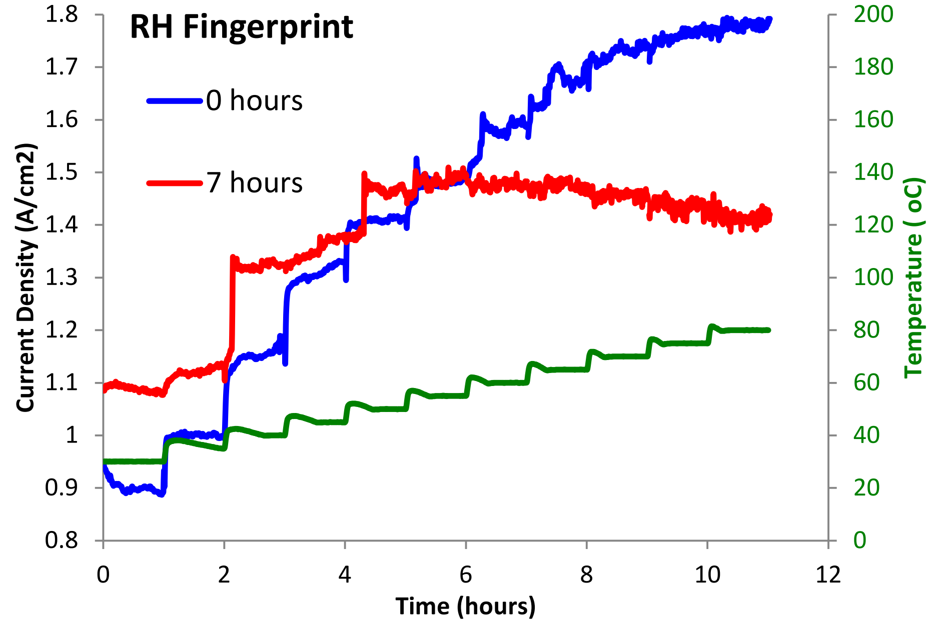
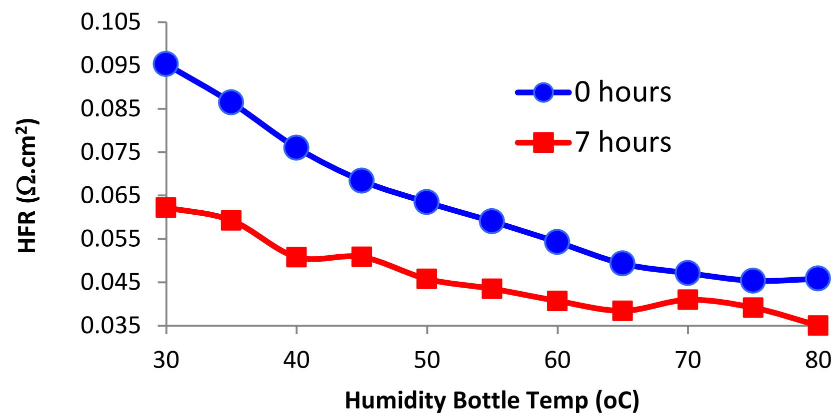


Figure 8.10. Comparison of RH-sensitivity scans for cells built with fresh SGL GDL 24BC (cell M5) and GDL 24BC aged in LAES chamber for 1006 hr (cell M2). Aging conditions were 80°C DI water and an air sparging gas; see Figure A.11 in Appendix A for cell M2 life-testing data.

David L. Wood III; Ph.D Thesis, UNM (2007)





- Ex situ ageing effects similar to in situ fuel cell ageing
- Lower HFR and better performance at low RH
- Decreased performance at high RH

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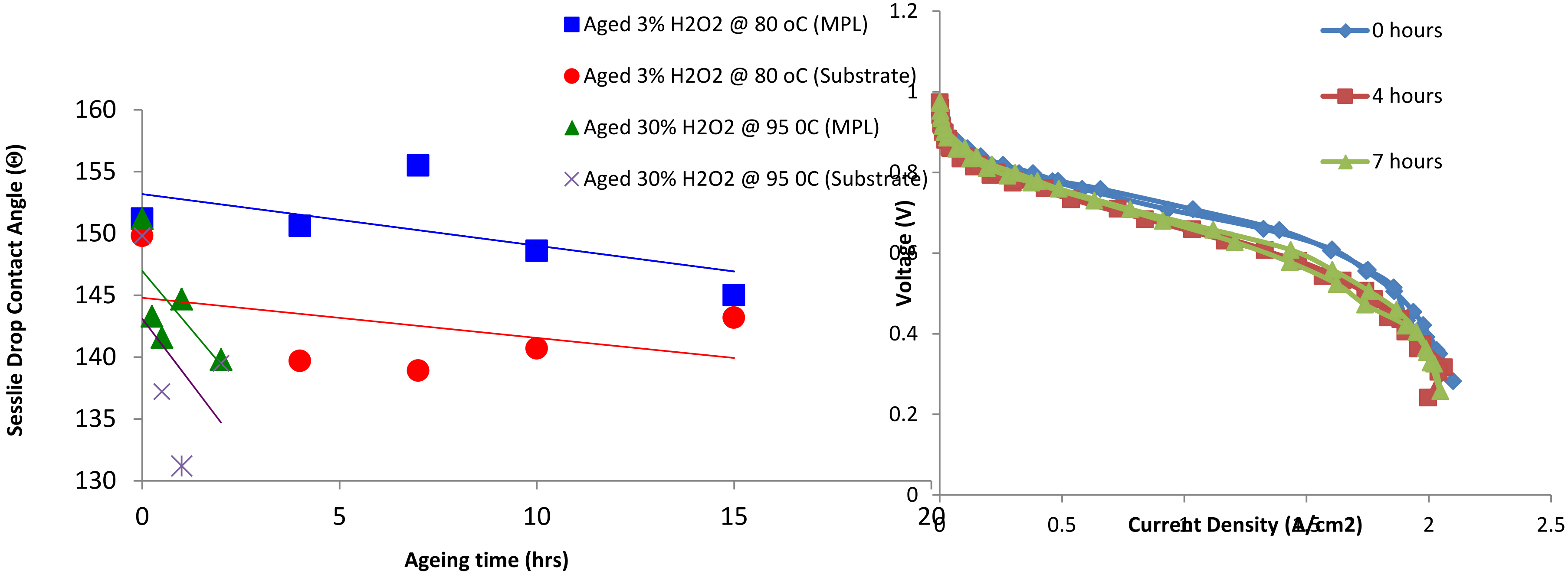
GDL AST : Operating Conditions

GDL AST



- Slower degradation observed after 80 °C ageing
- Initial tests indicate similar degradation rates in ex situ and in situ aged GDLs
- Further testing in progress using low loaded MEAs

Responses to Previous Year Reviewers' Comments

- Carbon corrosion at low potentials is reported to be significant @ 0.9 V; did the researchers quantify the value? Is there a dependence on the type or manufacturer of the carbon? Again, the information is somewhat elusive.
  - Carbon corrosion results have been presented in detail on three different carbons. The high surface area carbons have significant corrosion rates at those low potentials. These results have been published in ECS Transactions, 50 (2) 1589-1597 (2012).
- How does LBNL confirm the "collapse of cathode structure"? Is the collapse gradual or occurs at some catastrophic condition. Again, more information should be given.
  - The collapse of the catalyst layer is confirmed by TEM analysis at ORNL. LBNL utilizes this information in the VLB modeling. The loss is gradual (see slide from ORNL in reviewer only section).
- For the voltage loss breakdown analysis; what does simultaneous fitting of air and HelOx data at different current densities mean? Was the work done or is this a statement of future activity?
  - The fitting of data in air and HelOx simultaneously means that only the gas diffusion of O_2 is different and all other parameters are kept constant in fitting the polarization curve. This is done. A more robust fit would be the simulation the entire impedance spectrum and this is in the future work.
- The AST related to GDL ageing is not relevant for field failure.
  - We believe that these ASTs will be relevant when low loaded MEAs are used in the field.
- Study the impact of these ASTs on the state of the art MEAs.
  - Currently utilizing chemically and mechanically stabilized membranes and graphitized carbons. Will expand to include alloy work. Exploring possibility of using MEAs from GM.

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Collaborations

LANL (**Rangachary Mukundan, Rodney Borup, John Davey, David Langlois, Dennis Torraco, Karen Rau, Roger Lujan, Dusan Spernjak, Joe Fairweather and Fernando Garzon)**

- Co-ordinate project; Perform all ASTs and Drive cycle testing; Materials Analysis of BOL and EOL materials

Ballard Power Systems (Paul Beattie)

- Analyze Bus voltage cycling and RH cycling data

LBNL (Adam Weber)

- Detailed Voltage loss break-down and full AC impedance modeling

Ion Power (Steve Grot)
Deliver custom MEAs with varying durability

ORNL (Karren More)
TEM

W. L. Gore and Associates Inc., and SGL Carbon (materials suppliers)

Durability working group (Start/Stop protocol)

Future Work

- Evaluate modified FCCJ's catalyst cycling AST
  - Trapezoid wave with 0.5s rise time from 0.6V to 0.95V, 2.5s hold at 0.95V, 0.5s from 0.95 to 0.6V, and 2.5s hold at 0.6V @ 80 ^{o}C, 100% RH, H_2/N_2
- Expand into MEAs based on Pt-Ni alloy catalysts and low (Pt < 0.1 mg.Pt/cm^2)
- Perform DWG start/stop protocol on three different carbon based MEAs
- Evaluate catalyst layer AST including OCV testing and catalyst layer performance (0.6 to 1.2V cycle in H_2/Air)
- Evaluate RH cycling in H_2/Air using 1 min or 30 sec wet cycle time and 3 mins or 3.5 mins dry cycle time
- Continue long term drive cycle testing to evaluate effectiveness of membrane AST
- Model combined Mech/Chem degradation AST to try to accelerate it further
- Model voltage loss breakdown : include full impedance spectra

Summary

- New Carbon Corrosion AST
  - 1 to 1.5V cycling corrodes carbon 10X faster than 1.2V hold
  - 1 to 1.5V cycling results in ≈ 100X faster voltage, ECSA and MA decay and Pt particle size growth (Similar degradation mechanisms)
- Membrane AST
  - OCV too severe and RH cycling too benign to predict membrane lifetimes
  - RH cycling under OCV qualitatively similar to field and drive cycle data
    - RH cycling under OCV @ 80°C too benign (tests longer than 55 days, 20,0000 cycles for stabilized membranes)
    - RH cycling under OCV @ 90°C is faster but still needs acceleration of chemical degradation with respect to mechanical degradation (longer dry cycles)
- GDL AST
  - GDL AST results in similar degradation to that observed in drive cycle testing and in situ fuel cell testing
    - Quantification requires further testing

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W. L. Gore and Associates (MEAs)

SGL Carbon (GDLs)

Technical Backup Slides

Tech Team Protocol (Pt Catalyst)

Table 1
Electrocatalyst Cycle and Metrics
Table revised March 2, 2010

Cycle	Triangle sweep cycle: 50 mV/s between 0.6 V and 1.0 V. Single cell 25-50 cm^2	
Number	30,000 cycles	
Cycle time	16 s	
Temperature	80°C	
Relative Humidity	Anode/Cathode 100/100%	
Fuel/Oxidant	Hydrogen/N_2 (H_2 at 200 sccm and N_2 at 75 sccm for a 50 cm^2 cell	
Pressure	Atmospheric pressure	
Metric	**Frequency**	**Target**
Catalytic Mass Activity*	At Beginning and End of Test minimum	$\leq$40% loss of initial catalytic activity
Polarization curve from 0 to ≥1.5 A/cm²**	After 0, 1k, 5k, 10k, and 30k cycles	$\leq$30 mV loss at 0.8 A/cm^2
ECSA/Cyclic Voltammetry***	After 10, 100, 1k, 3k, 10k, 20k and 30k cycles	$\leq$40% loss of initial area

* Mass activity in A/mg @ 150 kPa abs backpressure at 857 mV iR-corrected on 6% H_2 (bal N_2)/O_2 {or equivalent thermodynamic potential}, 100%RH, 80°C normalized to initial mass of catalyst and measured before and after test.

** Polarization curve per Fuel Cell Tech Team Polarization Protocol in Table 5.

*** Sweep from 0.05 to 0.6V at 20mV/s, 80°C, 100% RH.

Tech Team Protocol (Catalyst Support)

Table 2 Catalyst Support Cycle and Metrics Table revised March 2, 2010		
Cycle	Hold at 1.2 V for 24 h; run polarization curve and ECSA; repeat for total 400 h. Single cell 25-50 cm^2	
Total time	Continuous operation for 400 h	
Diagnostic frequency	24 h	
Temperature	80°C	
Relative Humidity	Anode/Cathode 100/100%	
Fuel/Oxidant	Hydrogen/Nitrogen	
Pressure	150 kPa absolute	
Metric	**Frequency**	**Target**
Catalytic Activity*	Every 24 h	$\leq$40% loss of initial catalytic activity
Polarization curve from 0 to $\geq$1.5 A/cm^2**	Every 24 h	$\leq$30 mV loss at 1.5 A/cm^2 or rated power
ECSA/Cyclic Voltammetry***	Every 24 h	$\leq$40% loss of initial area

* Mass activity in A/mg @ 150 kPa abs backpressure at 857 mV iR-corrected on 6% H_2 (bal N_2)/O_2 {or equivalent thermodynamic potential}, 100%RH, 80°C normalized to initial mass of catalyst and measured before and after test.

** Polarization curve per Fuel Cell Tech Team Polarization Protocol in Table 5

*** Sweep from 0.05 to 0.6V at 20mV/s, 80°C, 100% RH.

Old AST

Tech Team Protocol (Catalyst Support)

Table A-2. Catalyst Support Cycle and Metrics Table revised January 14, 2013		
Cycle	Triangle sweep cycle: 500 mV/s between 1.0 V and 1.5 V; run polarization curve and ECSA; repeat for total 400 h. Single cell 25–50 cm^2	
Number	5000 cycles	
Cycle time	2 seconds	
Temperature	80°C	
Relative humidity	Anode/cathode 100/100%	
Fuel/oxidant	Hydrogen/nitrogen	
Pressure	Atmospheric	
Metric	**Frequency**	**Target**
Catalytic activity*	At beginning and end of test, minimum	$\leq$40% loss of initial catalytic activity
Polarization curve from 0 to $\geq$1.5 A/cm^2**	After 0, 10, 100, 200, 500, 1k, 2k, and 5k cycles	$\leq$30 mV loss at 1.5 A/cm^2 or rated power
ECSA/cyclic voltammetry***	After 0, 10, 100, 200, 500, 1k, 2k, and 5k cycles	$\leq$40% loss of initial area

* Mass activity in A/mg @ 150 kPa abs, backpressure at 857 mV iR-corrected on 6% H_2 (bal N_2)/O_2 {or equivalent thermodynamic potential}, 100% RH, 80°C normalized to initial mass of catalyst and measured before and after test.

** Polarization curve per Fuel Cell Tech Team Polarization Protocol in Table A-5.

*** Sweep from 0.05 to 0.6 V at 20 mV/s, 80°C, and 100% RH.

New AST

Tech Team Protocol (Membrane/Chemical)

Table 3
MEA Chemical Stability and Metrics
Table revised December 10, 2009

Test Condition	**Steady state OCV, single cell 25-50 cm^2**	
Total time	500 h	
Temperature	90°C	
Relative Humidity	Anode/Cathode 30/30%	
Fuel/Oxidant	Hydrogen/Air at stoics of 10/10 at 0.2 A/cm^2 equivalent flow	
Pressure, inlet kPa abs (bara)	Anode 150 (1.5), Cathode 150 (1.5)	
Metric	**Frequency**	**Target**
F^- release or equivalent for non-fluorine membranes	At least every 24 h	No target – for monitoring
Hydrogen Crossover (mA/cm^2)*	Every 24 h	$\leq$2 mA/cm^2
OCV	Continuous	$\leq$20% loss in OCV
High-frequency resistance	Every 24 h at 0.2 A/cm^2	No target – for monitoring
Shorting resistance**	Every 24 h	>1,000 ohm cm^2

* Crossover current per USFCC "Single Cell Test Protocol" Section A3-2, electrochemical hydrogen crossover method.

** Measured at 0.5V applied potential, 80°C and 100% RH N_2/N_2. Compression to 20% strain on the GDL.

Tech Team Protocol (Membrane/Mechanical)

Table 4 **Membrane Mechanical Cycle and Metrics** **(Test using a MEA)** **Table revised December 10, 2009**		
Cycle	**0% RH (2 min) to 90°C dewpoint (2 min), single cell 25-50 cm^2**	
Total time	Until crossover >2 mA/cm^2 or 20,000 cycles	
Temperature	80°C	
Relative Humidity	Cycle from 0% RH (2 min) to 90°C dewpoint (2 min)	
Fuel/Oxidant	Air/Air at 2 SLPM on both sides	
Pressure	Ambient or no back-pressure	
Metric	**Frequency**	**Target**
Crossover*	Every 24 h	$\leq$2 mA/cm^2
Shorting resistance**	Every 24 h	>1,000 ohm cm^2

* Crossover current per USFCC "Single Cell Test Protocol" Section A3-2, electrochemical hydrogen crossover method.

** Measured at 0.5 V applied potential, 80°C and 100% RH N_2/N_2. Compression to 20% strain on the GDL.

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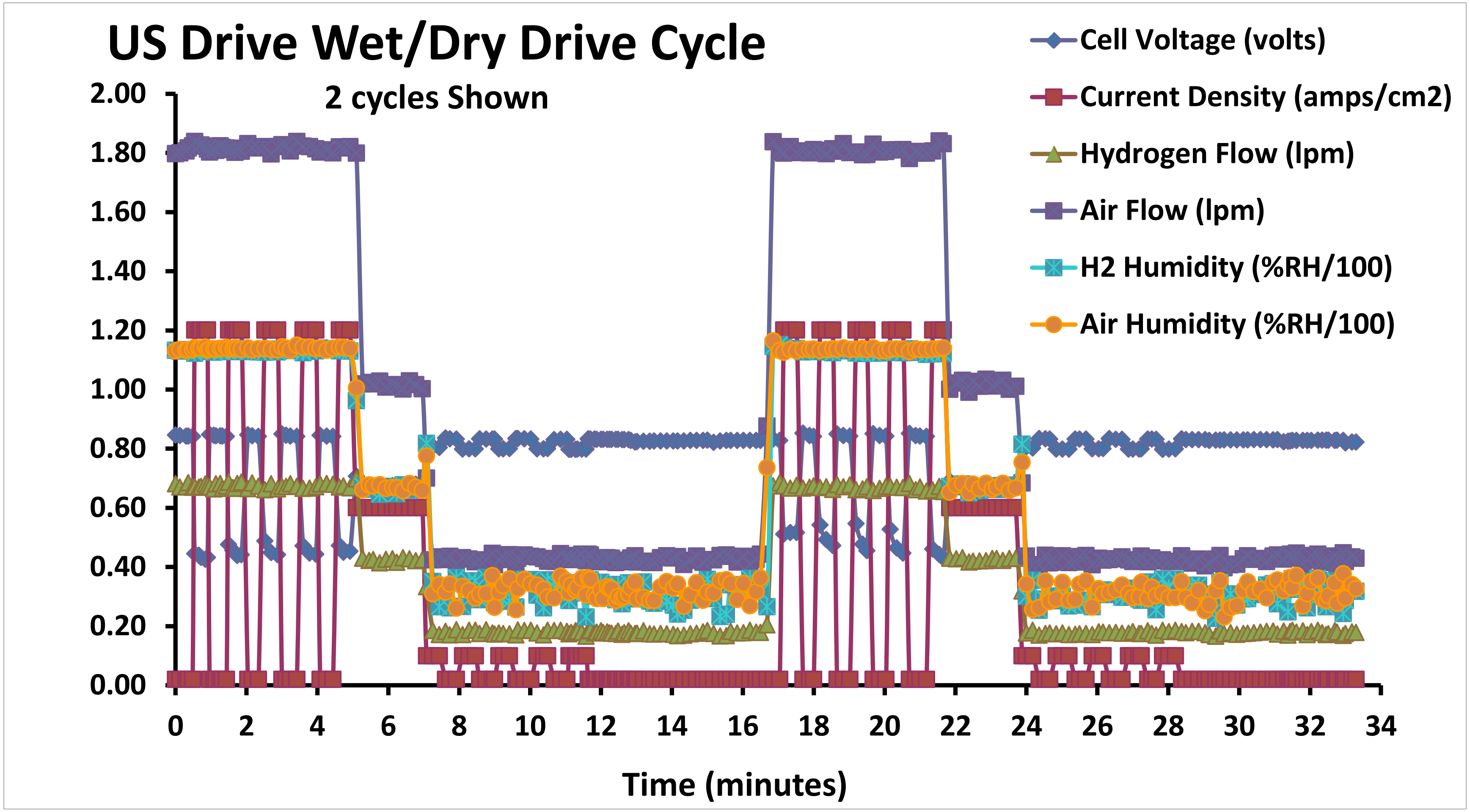
Drive Cycle Testing

Accomplishments /Progress



Use 100% H_2 instead of 80% H_2

Only one station capable of RH control (bottle = 90^{o}C, adjust dry and wet flows)

Also performing cycles at the high RH conditions (Wet Cycling)

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